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ABSTRACT

Approximately 700 Mexican American and Anglo students in grades 9, 10, and 11, who were identified as having superior mathematical ability, were surveyed to identify the factors affecting mathematics participation, determine the relative importance of these factors, and determine their stability over time. Five variables were studied: cognitive style, alienation, language environment, acculturation, and locus of control. Dependent variables were planned participation in high school mathematics and grades achieved in math classes. Students were given the Math-Related Decision Instrument, which measured the influential decision factors and the degree of influence of each variable; and the Group Embedded Figures Test, which determined cognitive style. Two-way analyses of variance were used to determine if sex or ethnicity affected the score obtained on the cognitive style measure or the number of math courses a student planned to take in high school. Findings indicated that cognitive style was significantly related to both planned math participation and grades in mathematics; the more alienated a student felt the fewer math courses were planned; sex was a determining factor in a student's planned mathematics participation while ethnicity was not; and locus of control significantly affected the number of math courses a student planned to take. (NQA)

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Factors Influencing Mathematics Participation of Highly Able Mexican American Adolescents

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Factors Influencing Mathematics Participation of Highly Able Mexican American Adolescents

A review of the literature supports the current belief that underrepresentation of Mexican American students in mathematics-related majors is indeed a problem of national concern. Educational Research in America, 1975, indicated that although in 1974 approximately 5.2% of the U.S. population was Mexican American, less than .6% of the total doctorates awarded in the mathematical sciences went to this ethnic group.

The Office of Communication Services, National Association of State Universities and Land Grant Colleges, reported in April 1979 that of the undergraduates enrolled during the Fall of 1978 only 2.2% were Hispanic. Further, only 1.5% of the graduate student population was Hispanic. Another publication (Glover, 1979) reported that minorities are grossly underrepresented in the field of engineering. In 1974, Spanish surnamed students made up 1.5% of the engineering graduates but 5.2% of the general population.

The student population at Arizona State University during the Fall 1979 semester numbered 37,755. Of this enrollment only 4.2% was Hispanic while Hispanics comprise 18.7% of the total population in the State of Arizona.

Arizona State University is not unique in its lack of math-science Mexican American students. Preparation for professional careers in mathematics and the physical sciences is, on the whole, open only to those college students who pursued the sustained study of these subjects in secondary school. Lack of advanced high school mathematics preparation constrains many future educational and occupational choices. It is, therefore, the intent of this study to investigate the cognitive, affective, educational, and social determinants of one's decision to take or not to take mathematics courses, to trace the development of the decision to avoid or participate, and to test the stability of the significance of the influencing factors over time. Results from the study will include suggestions for future interventions that will divert a greater portion of this minority group into the creation and dissemination of scientific knowledge.

The survey approach is particularly appropriate for a baseline study in an area as complex as Mexican American persistence in advanced mathematics where the diversity of factors and their relationships may suggest many possible explanations. Previous studies dealing with women and mathematics show a lack of agreement regarding the significance of suggested variables on participation. Studies pertaining to other minorities looked at only a few variables at a

time and most sample sizes were small resulting in a lack of statistical power. A large scale survey such as that used in this study (700 students) is one way to avoid problems produced by earlier limited samples. Thus, a major significance of this study will be in determining the degree to which each of the possible variables effect Mexican American students' decisions to pursue advanced mathematics courses in high school.

The Problem

This study addresses a problem of national concern: under-representation of Mexican Americans in math related college majors. The purpose of the research study is to investigate the cognitive, affective and social variables related to the development of interest, self-confidence and persistence in mathematics and mathematically related careers. Several factors are being studied including perceived influences of home, school and significant others. Additionally, culturally unique traits such as language environment, alienation, value orientation and cognitive style are also being investigated.

A review of the literature suggests the following general questions:

What variables constrict student's math-related career decisions?

What is the degree of influence of these variables?

Are the variables and the degree of influence stable over time?

Instruments

The team of investigators--a mathematics educator, a mathematician, and a social scientist--have developed and field tested the instrument to be used in this study.

The Math-Related Decision Instrument is designed to measure which of the possible decision factors are indeed influential in the student's decision to persist in mathematics at the time of administration. Further, the instrument measures the degree of influence of each variable using in most cases a 5 point Likert type scale.

After reviewing the literature the following categories of variables were tested:

1. Career related variables,
2. Attitudes relating to math and self,
3. Perceptions of mathematics,
4. Parental attitudes,
5. Significant others,
6. Demographic variables,
7. Cognitive style,
8. Language environment,
9. Acculturation,
10. Alienation,
11. Value orientation, and
12. Locus of control.

Several resources were used to construct this instrument including the Fennema-Sherman Mathematics Attitude Scale (1976) which has been modified by Armstrong (1979) and the various career related instruments. The instrument was administered at the beginning of the 1981-82 school year.

The Group Embedded Figures Test was used to determine cognitive style. The version is that adopted by the National Longitudinal Study of Mathematics Abilities (NLSMA) from the Educational Testing Service original (French, Ekstuem, and Price, 1963).

In addition to the study survey, a select subsample of parents is being interviewed. These are evenly split between (1) those with high ability and pursuing mathematics and (2) those with high ability and avoiding mathematics. These clinical interviews will serve as (1) a cross check for the student questionnaire and (2) a source of additional culturally relevant information.

Description of Sample

Upon completion of field testing and validation of the instrument, the random sample was chosen. Many Mexican American students who have high math ability decide to avoid the subject and thus lock themselves out of professions and careers that are math related. For this reason, the sample consisted of approximately 115 Mexican American students in each of grades 9, 10, and 11 who were identified as having superior mathematical ability based on a standardized

achievement test (CAT). This test was administered by the state to all students in April 1981. Additionally, a matched comparison group of Anglo students was selected using the same criteria making a total of about 700 students across the state to be tested.

Procedure

The survey was administered to all 700 students by the middle of November 1981. In total 31 schools in 18 school districts around the state were involved.

All students selected at a school were brought together in a central location and given the GEFT followed by the survey. Both instruments took approximately 90 minutes in total. In order to avoid biased interview responses, the subjects were not told the actual purpose of the study. They were asked to respond honestly to the questions in order that we might make some decisions that would improve schools for all students in Arizona.

Theoretical Basis and Statistical Procedures

Upon collection of the data, appropriate path analysis techniques are being used to test the degree of influence of decision related variables. Additionally, appropriate correlations are being applied to test for significant relationships between influential factors and decisions that are made. The path model will be employed to determine the casual links between the significant variables which would lead to persistence or lack of persistence of

the subjects in pursuing a career in mathematics. Upon completion of data analysis specific recommendations for educational decision making and implications for intervention strategies will be evident.

Preliminary Results

Five of the twelve independent variables will be discussed in this sections:

1. Cognitive Style,
2. Language Environment,
3. Acculturation,
4. Alienation,
5. Locus of Control.

These were chosen because they are of major importance in the literature dealing with Mexican American students and school in general. Pearson correlations were applied to the independent variables and the two dependent variables: (1) number of years of planned math participation and (2) grades in math courses.

Three correlations reached the required level of significance, $p < .05$ (see Table 1). Cognitive style was significantly related to both planned math participation ($r = 0.0977$, $p = 0.006$) and grades in mathematics ($r = -0.1511$, $p = 0.001$). The negative correlation is due to a coding effect in which a lower grade was given a higher score. It appears at this point in the analysis that the more "field independent" the student is the more math courses he plans to take and the better his grades will be.

Table 1

Correlations Between Planned Math Courses,

Grades in Mathematics and Selected Study Variables

	Planned Math Courses	Grades
Alienation	- 0.0701 p = 0.035*	- 0.0148 p = 0.351
Locus of Control	0.0588 p = 0.065	0.0050 p = 0.449
Language Environment	0.0087 p = 0.412	0.0469 p = 0.113
Cognitive Style	0.0977 p = 0.006*	- 0.1511 p = 0.000*
Acculturation	- 0.0011 p = 0.489	0.0464 p = 0.116

* Attained criterion level of significance

Additionally, alienation was found to be significantly related to the number of courses a student plans to take ($r = - 0.0701$, $p = 0.035$). The negative correlation suggests that the more alienated a student feels the fewer math courses he plans to take. Significance did not occur in the other seven tests. Language environment, acculturation, and locus of control were not found to be significantly related to math participation or grades achieved. Locus of control, however, tended toward the acceptable level of significance in relationship to planned math courses.

A two-way analysis of variance was used to determine if sex or ethnicity make a difference in the score obtained on the cognitive style measure. The resultant values are shown in Table 2. Based on this test it appears that performance on a cognitive style test is affected by both sex and ethnicity but the interaction effect is not significant.

Table 2

ANOVA, Cognitive Style by Sex and Ethnicity

Source	SS	df	MS	F	p
S (sex)	103.935	1	103.935	5.488	0.019*
E (ethnicity)	77.151	1	77.151	4.074	0.044*
S x E	20.435	1	20.435	1.079	0.299

* Attained criterion level of significance

A second two-way analysis of variance was applied to determine if sex or ethnicity make a difference on the number of math courses a student plans to take in high school. From Table 3 it should be noted that sex significantly affected the number of math courses planned but ethnicity and the interaction did not.

Table 3

ANOVA, Planned Math Courses by Sex and Ethnicity

Source	SS	df	MS	F	p
S (sex)	4.414	1	4.414	5.486	0.019*
E (ethnicity)	0.014	1	0.014	0.017	0.896
S x E	1.437	1	1.437	1.786	0.182

* Attained criterion level of significance

Based on the above findings, the investigators decided to use analysis of covariance measures on the data for the purpose of determining possible effects of cognitive style, locus of control and alienation when using sex and ethnicity as covariates. Four of the six tests showed significance at the $p < .05$ level.

Table 4

ANCOVA, Grades in Mathematics by Sex and Ethnicity

With Cognitive Style

Source	SS	df	MS	F	p
Cognitive Style	7.944	1	7.944	15.910	0.000*
S (sex)	0.059	1	0.059	0.117	0.732
E (ethnicity)	0.835	1	0.835	1.672	0.196
S x E	0.001	1	0.001	0.002	0.961

* Attained criterion level of significance

From Table 4 is should be noted that cognitive style appears to be significant while neither sex nor ethnicity reached the criterion level. This finding suggests that cognitive style did have an effect on the grades attained in mathematics classes. Further, this difference occurred regardless of sex or ethnicity.

The findings were different, however, when number of planned mathematics courses was the dependent variable (see Table 5). The statistical tests showed that cognitive style made a difference in the number of math courses a student planned to take in high school. Additionally, the sex of the student also had a significant effect.

Table 5

ANCOVA, Planned Math Courses by Sex and Ethnicity With Cognitive Style

Source	SS	df	MS	F	p
Cognitive Style	4.085	1	4.085	5.102	0.024*
S (sex)	3.691	1	3.691	4.610	0.032*
E (ethnicity)	0.070	1	0.070	0.087	0.768
S x E	1.263	1	1.263	1.577	0.210

* Attained criterion level of significance

Locus of control significantly affected the number of math courses a student planned to take (see Table 6). The sex of the student also made a difference but the effect of ethnicity was not significant.

Table 6

ANCOVA, Planned Math Courses by Sex and Ethnicity

With Locus of Control

Source	SS	df	MS	F	p
Locus of Control	3.713	1	3.713	4.646	0.032*
S (sex)	5.174	1	5.174	6.474	0.011*
E (ethnicity)	0.016	1	0.016	0.020	0.886
S x E	1.250	1	1.250	1.564	0.212

* Attained criterion level of significance

The fourth area of significance was that of alienation. The degree of alienation a student felt had no effect on attained grades in mathematics but it did have a significant effect on the number of math courses a student planned to take. The results are shown in Table 7. It should be noted, also, that once again sex had a significant effect but ethnicity did not.

Table 7

ANCOVA, Planned Math Courses by Sex and Ethnicity

With Alienation

Source	SS	df	MS	F	p
Alienation	4.132	1	4.132	5.165	0.023*
S (sex)	4.414	1	4.414	5.519	0.019*
E (ethnicity)	0.014	1	0.014	0.017	0.896
S x E	1.172	1	1.172	1.465	0.227

* Attained criterion level of significance

Discussion

The purpose of this study is to identify the factors affecting mathematics participation, determine the relative importance of these factors and determine their stability over time. At this point, analysis has begun on five of the twelve study variables: cognitive style, alienation, language environment, acculturation and locus of control. Planned participation in high school mathematics and grades achieved in math classes have been used as dependent variables.

Planned Participation

Planned mathematics participation refers to the number of years of mathematics a student plans to take while in his four years of high school. In the analysis of variance test, sex was found to be

a determining factor while ethnicity was not. The difference found in planned course taking always favored males. It should be noted, however, that no significant interaction existed between sex and ethnicity which suggests that girls in general plan to take fewer courses than their male counterparts. Mexican Americans and Anglos seemed to be equally optimistic about how much high school math they should take.

The "Group Embedded Figures Test" was used to determine cognitive style. In the analysis of variance test the score (1 - 18) attained on the GEFT was directly affected by both sex and ethnicity. The interaction, however, was not significant. These results indicate that females scored lower than males and Mexican Americans scored lower than Anglos. A lower score indicates a more field dependent style of learning. Since no significant interaction existed it can be assumed that no internal hierarchy occurred.

The analysis of covariance test using cognitive style while controlling for sex and ethnicity resulted in cognitive style and sex being significant factors while ethnicity was not. The implication, therefore, is that "field dependent" learners plan to take fewer math courses than field independent learners. Further, "field dependent" females plan to take fewer number of math classes than any other category. Both findings suggest that cognitive style may be a crucial factor in the decision to avoid or persist in mathematics.

Two other variables showed significance in their effects on planned math participation. Locus of control was one and alienation was the second. Internal-External locus of control refers to the extent to which persons perceive a connection between their actions and the outcomes. A high internal score is associated with a goal-oriented achievement conscious individual. The motivation for action comes from within. The analysis of covariance test indicated that students with an external locus of control planned to take fewer math courses than those who were internal. Additionally, females with an external locus of control planned to take less courses than any other group. This variable, however, did not significantly effect Mexican American students.

Alienation is defined as a feeling of "apartness from society" and "powerlessness". The statistical tests reveal that those students with a high degree of alienation planned to take fewer courses than those who feel more a part of society. Further, highly alienated females are the least optimistic about the number of math courses they might take.

Grades in Mathematics

Cognitive style is the only variable that proved to be a significant factor in determining differences in grades among the sample. Neither sex nor ethnicity played any part in this outcome. This result suggests that field dependent learners tend to get

lower grades in mathematics regardless of sex or ethnicity. Additionally, we know from the previous analysis that females tend to be more field-dependent and plan to take fewer math courses, but once they are in the courses sex does not effect grades.

In summary, the factors influencing participation in mathematics are numerous and complex. Results reported here are preliminary at best. Many additional statistical tests are needed before final conclusions can be made. It appears, however, that sex differences still remains at underlying thread throughout the variables studied here. Further, cognitive style is of major importance and needs intensive analysis. Its effects are significant on planned participation and grades as well as itself being affected by sex and ethnicity. Alienation and locus of control appear to be of some importance and will also be given deeper analysis. It is important to note that at this point most of the factors which seem to affect participation are the same for Mexican Americans and Anglos.

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